Amendments to the Drawings

I have added a new drawing sheet containing four figures to the application to clarify the claims.
The configuration shown in FIG. 6 supports Claim 1.
The configuration shown in FIG. 7 supports Claim 2.
The configuration shown in FIG. 8 supports Claim 3.
The configuration shown in FIG. 9 supports Claim 13.

The new figures do not add any new material. They clarify the material pictorially shown in FIGS. 1, 2, 3 and 4. The one-way pressure relief valve and parallel one-way vacuum relief valve are shown in FIG. 1, 2 and 4 embedded in the pressure cap as pressure relief valve (10) and vacuum relief valve (18). Sub-elements of the one-way pressure relief valve (10) are the pressure spring (15) and seal area (11), which set the relief pressure. Sub-element of the one-way vacuum relief valve (18) is spring (16) which sets vacuum opening pressure. The new FIGS. 6, 7, 8 and 9 show the pressure relief valve (10) and vacuum relief valve (18) and their plumbing configuration schematically, so their placement and plumbing can be easily seen. This is important, because the claimed invention is based on the pressure relief valve (10) and vacuum relief valve (18) and their placement between the closed-loop and atmospheric reservoir (12).

Remarks/Arguments

The amended specification contains no new material. **My signature on this letter is my declaration that no new material is included in the amended specification, drawings or claims submitted herein.**

I have narrowed my claims to reflect what I believe represents an advance over the prior Patented state of the art. I claim a device to keep the heat transfer loop between solar collector and hot water tank, filled completely with an automotive type antifreeze/water mixture, where air is removed from the heat transfer fluid by the normal thermal expansion of the heat transfer fluid in the day and its subsequent vacuum caused by thermal contraction upon cool down at night. Excluding the non-condensable gases, such as air, is important, because air speeds up corrosion by causing the antifreeze water mixture to oxidize and form acids, which can corrode the containment metals, like copper and brass.

The boiling-activated radiator system claimed is capable of safely dissipating the heat collected by the solar collector to the outside air if fluid circulation stops, by allowing the fluid to boil under pressure in the solar collector, the steam then moves up due to its lower density to the pressurized radiator where it is condensed back into water giving up its heat to the surrounding air. The steam-based heat pipe from the solar collector to the pressurized radiator depends on the buoyancy of steam in hot water to rapidly move the steam from the solar collector to the pressurized radiator. Non-condensable gases reduce the heat pipes' effectiveness at cooling the solar collector. Hence non-condensable gas removal is important.

I have also claimed a pressure-actuated damper system to dissipate solar collector heat if the fluid circulation stops. When boiling takes place in the solar collector the steam pressure activates a mechanism which opens air valves on the top and bottom of the solar collector allowing air to flow over the heat absorber and cools it sufficiently to stop the boiling. I believe the air exclusion system, pressurized liquid-to-air radiator and pressure-actuated dampers have not been anticipated nor claimed by the prior art.

The solar closed-loop fluid expansion/contraction device in Claim 1:

Claims the use of a one-way out pressure relief valve and one-way in vacuum recovery valve plumbed in parallel between the highest point in the solar collector loop and the bottom of a reservoir of heat transfer fluid at atmospheric pressure which is used to both regulate the pressure of the solar collector to hot water tank pumped closed-loop and expel air from the closed-loop and keep it from re-entering the closed-loop.

The heat transfer fluid contained in the circulation closed-loop between the solar collector and hot water tank is unpressurized when cold and increases in pressure as the

temperature of the heat transfer fluid is raised. This happens because the volume thermal expansion of the fluid is much greater than the volume expansion of the metal containing it. I recite a fluid loop which is full of fluid only, no air which is compressible, and uses a pressure relief valve to allow expanding fluid to leave the closed system at about 16 psig, so as temperature continues to increase, more fluid leaves the system. As fluid cools from maximum temperature, the pressure drops as the fluid contracts, at about -2 psig; fluid is allowed to re-enter the closed-loop from the reservoir, via the one-way vacuum relief valve.

The pressure in the system is maintained between the upper limit set by the one-way out pressure relief valve and the lower limit set by the one-way in vacuum relief valve. When the system is cold it is unpressurized. The fluid exiting and returning to the closed system is stored in a reservoir, where the fluid level is always above the inlet/outlet of the reservoir. This allows air expelled from the closed-loop to escape to the atmosphere, and does not allow air to get back into the closed-loop system.

In Embree (US 4269167) the system is pressurized with air to four psig, with water as the heat transfer fluid and several cubic feet of air, so the air can displace the fluid in the solar collector so the fluid can drain back out of the collector and piping. Embree controls pressure in his system by having a large volume of compressible air in the fluid loop, so the thermal expansion of the fluid cause only a very small pressure increase. Embree does not anticipate a system full of water-based automotive type antifreeze fluid, without an air volume to allow for fluid expansion and contraction. His system is under pressure when cold.

Scharfman (US 4043317) He does not claim the use of pressure to activate his collector cooling dampers, because his solar collector is self contained and could be used with any suitable heat transfer loop, pressurized or un-pressurized. He recites no means of controlling pressure in a closed-loop

Sigworth, Jr. (US 4413615) recites a sealed (closed-loop) solar system that uses heat transfer oil between the solar collector and storage tank. He uses thermal buoyancy forces to move the fluid with a simple backflow check valve. He uses an expansion tank (34) in his FIG.1 to manage system pressure. The tank has a volume of compressible gas. As temperature rises and the heat transfer fluid expands the gas is compressed and the system pressure raises a small amount. Upon system cool down the fluid contracts, the gas expands and pressure drops. Sigworth does not anticipate a heat transfer loop full of only fluid.

Zinn (US 4413615) recites the umbilical that I had claimed as claim 4. I have canceled this claim, since it is already patented.

I believe that the improvements in Claim 1 are not anticipated by the patents cited above when taken together. The patents cited above, do not anticipate a solar closed-loop

completely full of fluid. They do not anticipate a one-way out pressure relief valve to allow air and heat transfer fluid out, plumbed in parallel with a one-way in vacuum relief valve with an overflow/recovery reservoir allowing only liquid to be returned to the system via a vacuum relief valve.

The improvements derived from maintaining the closed-loop pressure between the upper limit set by the one-way out pressure relief valve and the lower limit set by the one-way in vacuum relief valve and air elimination are significant and not obvious. Air elimination prevents normal water-based automotive type antifreeze oxidation by air to form acids. Lower acid formation reduces corrosion, which increases the system life. Increasing and controlling pressure keeps hot, dry pockets of air from forming in the collector where the fluid has boiled out. Antifreeze temperatures over 300° Fahrenheit can occur and will oxidize the antifreeze rapidly causing it to turn dark and become strongly acidic and corrosive, dramatically decreasing system life. I believe that the combined benefits of air elimination and parallel pressure relief and vacuum relief valves together are not obvious to those skilled in the art based on the patents cite.

The boiling-activated pressurized liquid-to-air radiator closed-loop over-temperature device Claim 2:

Claims the use of a boiling-activated pressurized liquid-to-air radiator between the highest point solar collector fluid loop and the one-way out pressure relief valve and one-way in vacuum recovery valve plumbed in parallel between the liquid-to-air radiator and the bottom of a reservoir of heat transfer fluid at atmospheric pressure which is used to both regulate the pressure of the solar collector to hot water tank pumped closed-loop and expel air from the closed-loop and keep it from re-entering the closed-loop.

The solar collector will begin boiling at 265° Fahrenheit if the fluid circulation stops, since the pressure relief valve is set at 16 psig. The steam from the solar collector makes its way toward the pressure relief valve through a liquid-to-air radiator. Before the steam gets to the pressure relief valve, it encounters the pressurized liquid to air radiator, where it condenses from steam back into liquid. Most of the steam never gets to the pressure relief valve, where it could exit the pressurized fluid loop and be injected into the bottom of the overflow recovery reservoir, where it would be condensed into liquid by the liquid in the reservoir. Any steam left in the solar collector when the sun goes down will condense causing a vacuum in the solar collector fluid loop. This causes the vacuum relief valve to open letting fluid from the bottom of the overflow reservoir reenter the closed fluid loop. Air over the fluid in the reservoir can not enter the closed fluid loop, since the inlet/otlet of the reservoir is always below fluid level.

Prior art Goto et al (JP 59-93149 A) recites that the solar collector with water-based antifreeze fluid which will boil at 220° Fahrenheit. Goto's system is open to the atmosphere via vent tube (8). His system is considered an open loop because it is open

to the atmosphere. Goto does not recite any valves between his radiator and atmospheric pressure, because his system is open to the atmosphere at all times. Goto does not recite a pressure relief valve, vacuum relief valve or overflow reservoir, to keep the system full of fluid. The Goto system looks very similar, but his radiator is un-pressurized so a 50/50 water/antifreeze mixture would boil at 220° Fahrenheit, much lower than the 265° Fahrenheit I claim using 16 psig pressure. Goto et al does not recite a method to keep air out of his system.

The improvements derived from the pressurized radiator are significant, and not anticipated by Goto et al.

The pressure-actuated piston damper over-temperature protection Claim 3:

Claims the use of a pressure-actuated piston and air dampers, where the piston pressure inlet is connected between the highest point solar collector fluid loop and the one-way out pressure relief valve and one-way in vacuum recovery valve plumbed in parallel between the liquid-to-air-radiator and the bottom of a reservoir of heat transfer fluid at atmospheric pressure which is used to both regulate the pressure of the solar collector to hot water tank pumped closed-loop and expel air from the closed-loop and keep it from re-entering the closed-loop.

The solar collector damper activation unit uses the pressure generated by the solar collector boiling at about 265° Fahrenheit to open airflow dampers on solar collector. This system uses the steam pressure to operate a piston to open the dampers on the solar collector. When the collector cools, the steam generation stops and the dampers close.

Scharfman (US 4043317) does disclose an over-temperature protection system using dampers to cool the solar collector if circulation stops. Scharfman recites exclusively temperature activation devices, expanding wax, bimetals, electronic temperature sensors and controlling actuators; however he does not claim system pressure as an actuating mechanism. Scharfman has the dampers, but no steam to operate them. Scharfman claims the collector as a free standing part of any heat transfer system, both pressurized as well as un-pressurized. Hence, he only claims means that do not depend on system pressure. I specifically claim pressure activation for a filled closed-loop antifreeze system, because in my system the pressure and temperature are defined by the pressure relief valve. Scharfman has no pressure relief valves, so he has no way to relate temperature to pressure. Hence he wisely chooses to limit his air damper control mechanisms to temperature driven devices.

The combined boiling-activated pressurized liquid-to-air radiator and pressure-actuated piston damper over-temperature protection Claim 13:

Claims the use of both a boiling-activated pressurized liquid-to-air radiator and a pressure-actuated piston and air dampers where both radiator and piston inlets are connected between the highest point of the solar collector fluid loop and the one-way out pressure relief valve and one-way in vacuum recovery valve plumbed in parallel between the liquid-to-air-radiator and the bottom of a reservoir of heat transfer fluid at atmospheric pressure which is used to both regulate the pressure of the solar collector to hot water tank pumped closed-loop and expel air from the closed-loop and keep it from re-entering the closed-loop.

Scharfman (US 4043317) does disclose an over-temperature protection system using dampers to cool the solar collector if circulation stops. Scharfman recites exclusively temperature activation devices, expanding wax, bimetals, electronic temperature sensors and controlling actuators; however he does not claim system pressure as an actuating mechanism. Scharfman has the dampers, but no steam to operate them. Scharfman claims the collector as a free standing part of any heat transfer system, both pressurized as well as un-pressurized. Hence, he only claims means that do not depend on system pressure. I specifically claim pressure activation for a filled closed-loop antifreeze system, because in my system the pressure and temperature are defined by the pressure relief valve. Scharfman has no pressure relief valves, so he has no way to relate temperature to pressure. Hence he wisely chooses to limit his air damper control mechanisms to temperature driven devices.

Prior art Goto et al (JP 59-93149 A) recites that the solar collector with water-based antifreeze fluid which will boil at 220° Fahrenheit. Goto's system is open to the atmosphere via vent tube (8). His system is considered an open loop because it is open to the atmosphere. Goto does not recite any valves between his radiator and atmospheric pressure, because his system is open to the atmosphere at all times. Goto does not recite a pressure relief valve, vacuum relief valve or overflow reservoir, to keep the system full of fluid. The Goto system looks very similar, but his radiator is un-pressurized so a 50/50 water/antifreeze mixture would boil at 220° Fahrenheit, much lower than the 265 ° Fahrenheit I claim using 16 psig pressure. Goto et al does not recite a method to keep air out of his system.

Applicant respectfully requests that a timely Notice of Allowance be issued in this case.

Respectfully Submitted,

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United States Patent Application **Docket Number: 10/085,175**

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Date of Filing: 2/27/2002
Federal R&D: None
Assignment: None
Related Applications: Internal Water Tank Solar Heat Exchanger (US 6,837,303 B2)

SOLAR HEAT TRANSFER SYSTEM (HTSPL), High Temperature Self-Pressurized Loop

BACKGROUND OF INVENTION

This invention pertains to the collection and the delivery of heat from a roof or a ground mounted solar collector panel to a hot water storage tank via the use of a self-pressurized, high~~er~~ temperature ~~fluid~~ fluid-filled loop, which eliminates non-condensable gases, such as air, from the fluid loop. The pressurized loop system utilizes a mixture of water and antifreeze or another suitable fluid is circulated via a pump. In addition, the system is self-protected from over-temperature and over-pressure if the circulating pump fails. The higher temperature, compared to an un-pressurized, fluid heat transfer loop allows for a smaller heat transfer area and hence a more compact hot water tank heat exchanger, and a small diameter (approximately two inch), flexible, insulated umbilical which contains both electrical and fluid tubing connections (approximately ¼ inch outside diameter tubing) to go both out and back from the hot water tank to the solar collector for ease of installation. This heat transfer loop system is unique since there are savings in materials for heat exchangers, piping, and insulation. The system also has ~~built~~ built-in air elimination, ~~self - protection~~self-protection from overheating and ~~automatic~~automatically keeps the system full of fluid ~~maintenance~~.

PRIOR ART

Most common solar collector systems are either ~~the~~ un-pressurized or pressurized via an air bladder expansion tank and make use of a large area heat exchanger external to the water tank to exchange heat from the solar loop to the city water pressure in the hot water tank. Un-pressurized collector heat transfer loops are limited to the boiling point of the water/antifreeze mixtures, typically a 50/50 mix, at atmospheric pressure of approximately 220–° Fahrenheit. A water/antifreeze mixture of approximately 50/50, pressurized to 14 ~~PSI~~psig, or approximately two atmospheres in the collector loop, will not boil until 265–° Fahrenheit. The higher operating temperature in the collector loop allows for small surface area, efficient, ~~small area~~ in the hot water tank, heat exchangers to be utilized, which do not disturb the normal tank stratification. Internal tank heat exchanger also eliminates the pump that would circulate water from the hot water tank through the external heat exchanger. The stratification of the normal hot water tank, hot on top and cooler on the bottom, is disturbed by circulating water from the hot water storage tank, through the external heat exchanger. It is important not to disturb the normal tank stratification because it decreases the normal gas or electric heater efficiency.

Some solar collectors use pressurized drinking water and flow this water through the solar collector to heat it before it goes to the hot water tank inside the house. Other systems called integrated collector storage have a roof-–mounted hot water tank above the solar collectors filled with drinking water. The fresh potable water is subject to freezing and must be heated electrically at night to keep the roof-–mounted solar collector or integrated solar collector/hot water tank from freezing during cold weather. Other systems circulate potable water through the solar collectors only when they are illuminated by the sun, and must drain this water out at night during freezing weather. Drain down systems send the solar collector water down the drain, and get new fresh

water the next day. Drain back systems have a holding tank that the solar collector water can drain into and be used over and over.

Main advantages: 1) Pressurized antifreeze heat transfer loops allow solar collectors and tank heat exchangers to operate up to 265-° Fahrenheit; 2) Pressurized heat transfer loops allow heat to be transferred with very low fluid flow rates minimizing pumping power and allowing small diameter tubes to take fluid to and from the solar collector and water tank heat exchanger; 3) Keeping the fluid loop full of fluid and eliminating non-condensable air minimizes corrosion of the fluid loop containment walls; 4) Internal small area heat exchangers adapt to existing tanks with minimum re-plumbing and without tank removal or draining; 5) Heat exchanger is efficient; 6) Double wall heat exchanger safely separates toxic heat transfer fluids from potable water; 7) This solar system costs less to install and maintain; and 8) Solar system maintains normal tank stratification.

SUMMARY OF INVENTION

In summary, the present invention is a closed fluid loop solar system which is unpressurized when cold and ~~self pressurized,~~ upon heating becomes self-pressurized ~~via~~ by fluid thermal expansion~~-on heat system heat up,~~. ~~fluid~~ The pressure is limited by a pressure relief valve which allows trapped gas and fluid to leave the closed-loop system and go to the overflow reservoir. Upon cool down the vacuum caused by fluid thermal contraction ~~filled and maintained full eliminating non-condensable air by the vacuum from fluid thermal and steam contraction,~~ drawing~~s~~ fluid back into the system from the overflow reservoir through a slightly sub-atmospheric vacuum relief valve. ~~from the overflow reservoir back into the fluid loop~~The normal daily heating and cooling cycles keeps the system full of fluid by automatically eliminating non-condensable gases such as air. ~~, where~~ ~~heat is collected in a~~ The solar panel illuminated by the sun, heats a solution of ~~water~~ water-based antifreeze or other suitable liquid, the fluid is pumped at low flow rate to a hot water tank where ~~it~~ the fluid ~~gives up the heat~~transfers heat via a heat

exchanger to the hot water tank. The fluid loop is self-pressurized and can operate above the normal boiling point of water 212-° Fahrenheit. The fluid loop also has a ~~built~~ built-in boiling and pressure-~~-activated~~ actuated over-temperature protection and over-pressure protection, so if the fluid circulation pump stops while the sun is shining the solar collector will not get too hot and damage itself, or make the heat transfer fluid more corrosive to the containment materials.

The primary objective of the present invention is to reduce the amount of material needed to collect and transport solar heat. This is accomplished by increasing the pressure and hence the temperature in the ~~maintained full~~ fluid filled loop, which decreases the area of the hot water tank to fluid loop heat exchanger surface needed. The higher fluid temperature difference, between the hot water tank and the solar collector, allows more heat to be stored in each unit volume of fluid in the solar collector heat transfer loop. ~~Hence~~ For a smaller volume of fluid, a lower flow rate is needed to deliver the heat from the solar collector to the hot water tank. The higher fluid temperature in the collector will lower the ~~collectors~~collectors' efficiency, since it is losing heat to the outside air. This loss is a small price to pay for a system using significantly less material.

Another objective is to reduce the time and complexity of retrofitting solar energy to existing homes, since it uses flexible small diameter tubing to carry the low fluid flow volume. The small diameter of the fluid carrying tubes, approximately ¼ inch outside diameter, also allows them to be thermally insulated and still be less than two inches in diameter. By adding an electrical wire bundle to the insulated fluid carrying tubes and wrapping them with a protective covering, an umbilical cord is created, which carries all fluids and electrical signals from the hot water tank to the solar collector. This plug and play umbilical allows for do-it-yourselfers or professionals to install the system more quickly. These fluid carrying tubes can be installed in existing buildings because they are flexible and can be fed into and through attics, walls and placed on the outside of buildings, without being unsightly.

Additional objectives, advantages and novel features of the invention will be set forth in the description which follows and will become apparent to those skilled in the art upon examination of the following. Others may be learned by the practice of the invention. The objectives and advantages of the invention may be realized and attained

by means of the instrumentalities and combinations particularly pointed out in the appended claims.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the pressurized loop solar collector system, including the fluid loop, the solar collector, the hot water tank heat exchanger, the fluid pump, controller, the over-pressure relief and ~~fluid full maintenance~~the vacuum relief ~~with~~ and overflow reservoir~~, –~~, and both ~~boiling~~ liquid-to-air radiator and pressure-~~activated~~ actuated air damper over-temperature systems.

FIG. 2 is a view of the boiling-activated solar collector over-temperature system including the pressurized ~~liquid-to-air radiator~~liquid-to-air radiator, the pressure relief valve, ~~and the fluid full maintenance system including~~ the vacuum recovery valve and ~~its external~~the overflow fluid reservoir.

FIG. 3 is a pressure-~~-activated~~ actuated solar collector over-temperature control system, which opens dampers in the collector to let heat out, when the fluid in the solar collector boils and ~~raises and~~ sustains the loop pressure to a point just below the regulated pressure.

FIG. 4 is a boiling-activated solar collector over-temperature control system, which forces steam from the boiling solar collector into a pressurized liquid-to-air heat exchanger/radiator, which uses fins to reject heat from the radiator and condense the steam back to water, and then return this water to the main heat transfer loop.

FIG. 5 is a plot of solar collector air valve position versus pressure in the solar collector fluid loop.

FIG. 6 Preferred embodiment of the pressure/vacuum management and air elimination device.

FIG. 7 Preferred embodiment of the boiling-activated pressurized radiator over-temperature protection device attached between the solar collector and the pressure/vacuum management and air elimination device.

FIG. 8 Preferred embodiment of the pressure-actuated piston air damper over-temperature protection device, with the pressure tap between the solar collector and the pressure/vacuum management and air elimination device.

FIG. 9 Preferred embodiment of both boiling-activated pressurized radiator over-temperature and pressure-actuated piston air damper over-temperature protection device, with both the pressure tap and pressurized radiator between the solar collector and the pressure/vacuum management and air elimination device.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The invention (FIG. 1) consists of a pressurized heat transfer loop (1, 14 &17~~,~~) which operates above the boiling point of water at one atmosphere of pressure, 212~~-~~° Fahrenheit. The heat transfer fluid (13) is heated, in the solar collector tube (1) by the sun. The solar collector (2) can be single, or double glazed. The heated fluid then exits the solar collector in tube (1) and comes to a three-way connection. Path one (7) goes to the pressure actuator (6), which can move the actuator arm (5) to actuate air dampers with motion (4). Path one may not be needed if the path two pressurized fluid/steam-to-air radiator is sufficient to prevent overheating. Path two goes through a pressurized radiator (8) with fins (9) to a pressure relief valve (10) which includes a vacuum recovery valve to let expelled heat exchanger fluid (13) back into the system from the fluid overflow/recovery reservoir (12), while excluding non-condensable air. Path three (14) is the fluid tubing leading to the hot water tank (22) heat exchanger (16). The insertable, internal heat exchanger is screwed into the tank through a tank port (24) and allows water

tank fluid (30) ingress or egress via a side port (26). The inside of the outer heat exchanger wall (16) is in physical contact with the outside of tubes (14 &17). Physical contact means that over a significant area or approximately 50% of the surfaces, the interfaces are compressed together mechanically so heat can cross the interface, but leaking liquid from either side will move along the interface. The tube (14) turns around in the bottom of the heat exchanger and becomes the tube (17) exiting the heat exchanger. The tubes (14 & 17) are much hotter than the water in the hot water tank (30) and are in physical contact with the wall (16) so the heat is transferred from the heat transfer fluid (13) through the first wall (14 or 17) then through the mechanical interface to the second wall (16) then into the water (30). Once the tube (17) leaves the heat exchanger it returns to the pump (20) inlet. The tube (17) then returns to the solar collector tube (1) for the heating of the fluid (13).

To transport the pressurized fluid and the heat it contains from the solar collector to the hot water heater a flexible insulated umbilical is used (15). The umbilical consists of thermally insulated fluid connections (14 & 17) from the solar collector (1 & 2) to the hot water tank, rubber closed-cell thermal insulation (32), the low voltage electrical connections and a weather resistant covering of polymer pipe (31), the two small diameter tubes (14 & 17) containing the solar collector heated fluid (13). This allows the two-tube bundle to be flexible and insulated (32) and still be less than 2 inches in diameter. The small copper tubes are connected together with standard tubing unions, angles and T-connectors of about ¼, 5/16, or 3/8 inch tube size.

The solar collector (2), an integral part of the collector, is a set of dampers which are opened by pressure (15). These dampers are only open when the solar heat collected is more than the hot water tank can use. These dampers when opened allow outside air of less than 120-^{o} Fahrenheit to flow over the absorber plate, where the sunlight is converted to heat and transferred into the heat transfer fluid. This airflow cools the absorber and stops the boiling. Then the dampers close and the absorber heats back up. The dampers open and close on a two to five minute cycle and only minor boiling is allowed to take place. This self-controlling feature is unique and allows the collector to protect itself, even if the fluid flow in the pressurized loop (1, 14 & 17) stops. Alternatively to the dampers, or along with them, one could use the boiling-activated radiator system shown

in (FIGS. 1, 2 ~~&~~ & 4~~,~~), which is a pressurized side channel to the main pressurized heat transfer loop, which is at the uppermost point in the main fluid loop. As steam bubbles form in the solar collector they try to escape by going into the side channel heat exchanger. The fluid there is below the boiling point of the pressurized fluid and they collapse and condense. The fluid in the side channel is cooler because the outer surface is exposed to the outside air via fins (9). If no bubbles are forming in the solar collector, then there is no flow of fluid in the side channel and the fluid in the side channel stays cool.

The system has two possible configurations for activating the heat transfer fluid pump (20). The first is a conventional control system run by household 115VAC power. This control system has a control box (52), which plugs into the wall outlet and has two sensors. The collector has a temperature sensor using low voltage (50), where the electrical wires are part of the umbilical to tell the controller, which turns on the pump, when the solar collector temperature exceeds the hot water tank temperature, which is measured by sensor (56) on the hot water tank. The sensor (56) is usually placed near the top of the tank (22), which tells the controller when the tank is getting too hot, i.e. no one home to use hot water, then the controller will shut off the pump. This would now cause the pressure damper or side channel heat exchanger to protect the collector from excessive boiling, which would block the collector solar collector tubes with mineral ~~deposites~~deposits over time.

The second pumping system is based on using a photovoltaic array (60), which provides 12 Volt power when the sun is shining. This power is carried down to the pump on the umbilical connector wire. The pump is a DC powered pump, which is capable of low flow at modest pressures. A control box may not be necessary. When the sun is out the pump ~~pumps~~is on, when ~~it~~ the sun is not out, the pump ~~stops~~is off. A thermal disconnection switch (64), is placed on the top of the hot water tank, so if the hot water tank gets too hot, it will disconnect the pump.

The invention also consists of a pressurized radiator, pressure relief and vacuum recovery valve, and fluid overflow recovery system (~~Fig~~FIG. 2). This system includes: a pressurized fluid radiator (8) with fins (9) to conduct heat from the fluid to the surrounding air; a reservoir (12); a pressure ~~cap~~ valve (10) to regulate the pressure in the

system; a vacuum relief valve (18) to -allow the overflowed fluid to return to the system upon cool down at night via the vacuum relief valve (18) which is shown built into the pressure ~~cap~~ relief valve (10) (FIG. 6 shows these valves are plumbed in parallel, with pressure relief (10) being one-way out and vacuum recover (18) being one-way in); a fluid overflow and recovery reservoir (12) to the pressure relief (10) and vacuum recovery (18) valves via tube (72) while excluding non-condensable air, since tube (72) enters the fluid (13) below the surface level. The pressure of the fluid in the solar collector heat transfer loop is regulated by the pressure cap, which uses a spring (15) to push against the fluid pressure over a fixed area (11). During normal daily operation when the sun is out, the heat transfer fluid (13) expands as it heats from 75-° Fahrenheit to over 230° Fahrenheit. When the pressure reaches the set pressure, i.e. 16 ~~PSIG~~psig, fluid and any trapped air is pushed out past pressure relief valve (10) -and overflows to the fluid overflow reservoir (12) via tube (72). In the overflow reservoir (12) -the fluid is retained and the air bubbles move from the bottom of tube (72) which is below the liquid surface to the liquid surface, burst and are vented to the atmosphere by a cap (70). At night, when the fluid and condensable steam in the solar heat transfer system cools and contracts, fluid only is drawn back through vacuum relief valve (18), by the vacuum in the fluid loop caused by fluid contraction. The vacuum relief pressure is set by spring (16) to about ~~minus two~~ 2 ~~PSIG~~psig, into the heat transfer system to keep it full of fluid and keep non-condensable air out. Air in the system increases the corrosion of the fluid loop. This simple system allows the approximately 50% water/50% antifreeze mixture in the solar heat transfer loop to heat up to over 212-° Fahrenheit, without boiling until it reaches almost 265-° Fahrenheit, at 16 ~~PSIG~~ psig confinement pressure. This higher temperature allows for heat to be transferred more efficiently into the hot water tank, using lower flow rates and a small surface area internal (or external) hot water tank heat exchanger.

The invention also consists of a pressure~~- activated~~ actuated solar collector over-temperature protection system (~~Fig~~ FIG 3). An integral part of the collector is a set of dampers (86 & 88) on both the top and bottom of the solar collectors, which are opened by pressure actuator (6). These dampers are only open when the solar heat collected is more than the hot water tank can use and the solar collector begins to boil. These

dampers, when opened, allow outside air of less than 120-° Fahrenheit to flow over the absorber plate (FIG. 1 (3)), where the sunlight is converted to heat and transferred into the heat transfer fluid. This airflow cools the absorber and stops the boiling. Then the dampers close and the absorber heats back up. The dampers open and close on a two to five minute cycle and only minor boiling is allowed to take place. This self-controlling feature is unique and allows the collector to protect itself, even if the fluid flow in the pressurized loop (FIG. 1. tubes 1, 14 & 17) stops.

The pressure~~- activated~~ actuated control system is needed if fluid circulation stops for any reason while the sun is shining, i.e. controller turns off pump, or pump failure, or power failure, or fluid loop blockage. The pressure~~- activated~~ actuated system consists of a solar system fluid pressure~~-activated~~ actuator (6), such as a piston (84), or other pressure~~-activated~~ actuator, which is in a retracted state at normal system operating pressure and in an extended state at the pressure cap relief setting, such as 16 ~~PSIG~~psig. A spring (82) or a pressurized cavity can be used to return the actuator to the retracted state, when the solar system pressure falls to normal operating pressure. The solar system fluid (13) is sealed into the system via a bellows (80) or another acceptable seal, such as an O-ring. The actuator is connected to the fluid loop (7). This actuator output (5) is connected via linkage (4) to a hinged or a sliding valve (86, 88), like a furnace damper, which allows air to flow over the solar collector absorber plate (~~Fig.~~FIG. 1. (1)) and cools ~~it off~~ the absorber plate with outside air. Over-temperature protection is achieved by successive airflow movements over the solar collector absorber plate. When the solar collector gets too hot the heat transfer fluid (13) boils in the solar collector. This causes the pressure actuator to extend and open the collector air damper valves into position (91), opening up holes (90) for air movement over the solar collector absorber plate (~~Fig.~~FIG. 1. (1)), which takes the heat out of the solar collector and the heat transfer fluid temperature drops below the boiling point and stops boiling. When the system pressure returns to normal, the actuator retracts and closes the solar collector air damper valves into position (92). This air valve open/close cycle repeats itself until the sun goes down, or until the fluid flow is re-established. Thus the collector prevents damage to the system by keeping the collector near the pressurized boiling point of the water/antifreeze mixture under non-circulation conditions. Non-circulation can occur normally if the hot water

tank is hot enough and the controller shuts off the pump and abnormally if the pump fails, power fails or the fluid flow path is blocked.

The invention also consists of a ~~boiling~~ boiling-activated solar collector over-temperature protection system (FIG. 4). The system consists of a pressurized ~~liquid-to-air radiator~~liquid-to-air radiator heat exchanger, and a boiling gas, steam/liquid, separator. During normal operation, the entire system is full of heat transfer fluid (13) and no boiling occurs. The liquid-to-air heat exchanger (8) with fins (9) is a side arm and usually has no fluid flow in it. Normally the fluid flows into the boiling gas separator (94) from the solar collector tube (1) and out of the boiling gas separator down tube (14) to the hot water tank (22). Under non-flow conditions, such as circulating pump failure or the solar input being greater than the hot water tank can ~~use,~~use the solar collector (2) will begin to boil. In this event, the boiling gas separator (94) allows the gas (steam) bubbles to go up by buoyancy into the liquid-to-air heat exchanger (8), which stirs the liquid in the heat exchanger, while condensing the boiling gas back to a liquid, and heats the heat exchange fins (9) above the outside air temperature and dissipates this heat from the pressurized liquid (13) in heat exchanger (8) to the outside air. The filler tube (92) allows condensed pressurized liquid to come from the liquid-to-air exchanger and be inserted below where the gas (steam) bubbles are being released tube (1) into the boiling gas separator (94) keeping the collector fluid loop (14 & 17) full of liquid, while liquid and gas, steam, exist in the collector (1) The water-based heat pipe system allows a small amount of boiling in the solar collector to take place; the generated steam travels up by buoyancy to the pressurized heat exchanger, which rejects heat to the atmosphere via the pressurized liquid (8) to the air radiator (9) heat exchanger. As long as solar collector boiling takes place, the pressurized liquid in the side arm heat exchanger (8) will be heated by condensing of the steam. Non-condensable air in the boiling solar collector will impede the flow of steam to the pressurized heat exchanger, so air must be kept out of the system. Only a small amount of fluid will be forced into a fluid overflow tube (72) into atmospheric reservoir (12). The advantage of this system over, the pressure-~~activated~~ actuated solar collector air vents, is that boiling-activated heat pipe system has fewer moving parts and can easily dissipate all of the heat that the solar collector can gather from the sun, without pump power circulation of the heat exchange fluid..

The graph in FIG. 5 shows the actuator and air valve position as a function of system pressure. The air valves (~~Fig~~FIG. 3 (90)) are in the shut position (~~Fig.~~FIG. 3 (92)) and the actuator retracted until a pressure of approximately 80% (102) of the system pressure, maintained by the pressure relief valve (~~Fig.~~FIG. 4. (10)) is reached. At pressures above (102) the air valves begin to open and are fully open by the time the system reaches 95% (104) of the system pressure maintained by the pressure relief valve. This arrangement allows the system to cool itself before vigorous boiling occurs. The pressure versus actuator position profile is determined by the piston area (~~Fig.~~FIG.3. (84)) and spring constant (~~Fig.~~FIG. 3. (82)~~)~~.

The preferred embodiment of the pressure/vacuum management and air elimination device is shown in FIG. 6. The pressure relief valve (10) limits the system pressure by allowing fluid to flow in one direction from the pressurized solar loop (1) to reservoir (12) at a set relief pressure, near 16 psig. Solar energy heats the fluid in the solar collector fluid loop (1) and it expands. Since the fluid loop is closed and contains only incompressible fluid and a very small amount of non-condensable gas, the pressure builds up rapidly until the pressure relief valve (10) set point is reached, then any gas trapped blows through the pressure relief valve (10) and fluid from the closed-loop also passes out through relief valve (10) through tube (72) into the bottom of reservoir (12) which holds unpressurized antifreeze fluid (13). Trapped gas then bubbles to the reservoir fluid (13) surface and back to the atmosphere. When the solar energy input ceases due to clouds or nightfall, the fluid in the solar collector fluid loop (1) contracts, causing a vacuum in the fluid loop (1). Antifreeze fluid (13) is drawn from the bottom of reservoir (12) through tube (72) through the one direction vacuum relief valve (18), set to about -2 psig, and back into the collector fluid loop (1). Air is eliminated from tube (72) because it is below the surface of antifreeze (13) in reservoir (12).

The preferred embodiment of the pressurized liquid-to-air radiator over-temperature device is shown in FIG. 7. Pictorial views of this pressurized liquid-to-air radiator over-temperature device are shown in FIGS. 2 & 4. The pressurized fluid-filled radiator (8) is connected between the solar collector and the pressure relief valve (10) and the vacuum

relief valve (18). The pressurized radiator (8) has fins (9) which allow heat to be conducted away from radiator (8) and given up to the surrounding air. Solar energy will cause solar collector fluid to turn to steam if there is no flow in the solar collector fluid loop (1). The steam follows a path to radiator (8) where the heat is conducted along the fins (9) and hence the surrounding air, which condenses the steam back to liquid water. This boiling and condensing under pressure keeps the solar collector from overheating. The pressure/vacuum management and air elimination device components; the pressure relief valve (10), vacuum relief valve (18), tube (72), reservoir (12) of atmospheric pressure antifreeze (13) are identical to FIG. 6 and function in the same way.

The preferred embodiment of the pressure piston-actuated air damper over-temperature device is shown in FIG. 8. Pictorial views of the piston and linkages are shown in FIG. 3. The pressure piston is connected via tube (7) between the solar collector fluid loop (1) and the pressure relief valve (10) and vacuum relief valve (18). Solar energy will cause solar collector fluid to turn to steam if there is no flow in the solar collector fluid loop (1). The steam makes its way to the pressure piston actuator (6) causing it to extend, which causes the actuator arm (5) to move and thus open the air dampers with motion (4). Outside air flowing over the solar collector panels containing the solar fluid loop (1) cools the fluid and the boiling stops. The pressure actuator (6) retracts, which causes the actuator arm (5) to move and thus close the air dampers with motion (4). This extension/retraction motion continues until the sun goes down or fluid circulation is restored. The pressure/vacuum management and air elimination device components; the pressure relief valve (10), vacuum relief valve (18), tube (72), reservoir (12) of atmospheric pressure antifreeze (13) are identical to FIG. 6 and function in the same way.

The preferred embodiment of both pressurized liquid-to-air radiator and pressure piston-actuated air damper over-temperature device is shown in FIG. 9. A pictorial view including both pressurized liquid-to-air radiator and pressure piston-actuated air damper over-temperature is shown in FIG. 1. Both the pressurized liquid-to-air radiator and pressure piston via tube (7) are connected between the solar collector fluid loop (1) and the pressure relief valve (10) and vacuum relief valve (18). Solar energy will cause solar

collector fluid to turn to steam if there is no flow in the solar collector fluid loop (1). The steam makes its way to both the liquid-to-air radiator (8) and the pressure piston actuator (6). If the liquid-to-air radiator (8) condenses the steam as fast as it is generated then the pressure piston (6) does not extend. If the liquid-to-air radiator (8) can not condense the steam as fast as it is generated then the pressure piston (6) does extend, which causes the actuator arm (5) to move and thus open the air dampers with motion (4). Outside air flowing over the solar collector panels containing the solar fluid loop (1) cools the fluid and the boiling stops. The pressure actuator (6) retracts, which causes the actuator arm (5) to move and thus close the air dampers with motion (4). This extension/retraction motion continues until the liquid-to-air radiator (8) can condense all of the steam, as a result of the sun going down or fluid circulation restoration. The pressure/vacuum management and air elimination device components; the pressure relief valve (10), vacuum relief valve (18), tube (72), reservoir (12) of atmospheric pressure antifreeze (13) are identical to FIG. 6 and function in the same way.

Claims

1. (currently amended): A ~~system~~ device to actively manage pressure/vacuum and eliminate non-condensable gases in a closed loop, unpressurized when cold, fluid filled, self-pressurizing, solar system~~, like air, from a solar collector to a hot water tank, antifreeze fluid filled, heat transfer loop, during every heat up and cool down cycle~~, which is ~~comprises~~comprised of: a one-way out pressure relief valve and a one-way in vacuum relief valve plumbed in parallel ~~placed at~~from the highest point in the solar system to ~~immediately above the solar collector; a pressure relief valve capable of maintaining the pressure, caused by fluid thermal expansion or water to steam phase change, above atmospheric pressure, thereby increasing the boiling point of the heat transfer fluid; a non pressurized~~the bottom of an unpressurized, partially filled overflow/recovery reservoir. ~~beyond the pressure relief valve apparatus to catch overflow heat transfer fluid and release non-condensable gases to the atmosphere; a vacuum relief valve, in parallel with the pressure relief valve, connected to the overflow/recovery reservoir below the water line, so fluid thermal contraction induced vacuum inside the fluid loop returns only the overflowed fluid to the fluid loop while keeping non-condensable gases out.~~

2. (currently amended): A ~~boiling activated~~ solar collector over-temperature protection ~~system~~ device which consists of boiling-activated, presssurized liquid-to-air radiator between the solar collector and the device to actively manage pressure/vacuum and eliminate non-condensable gases in a closed loop, unpressurized when cold, fluid filled, self-pressurizing, solar system, which is comprised of: a one-way out pressure relief valve and a one-way in vacuum relief valve plumbed in parallel from the highest point in the solar system to the bottom of an unpressurized, partially filled overflow/recovery reservoir. ~~for pressurized, antifreeze filled, fluid heat transfer loop from a solar collector to a hot water tank, which includes a condensable gas (steam) heat pipe to carry excess heat from the boiling solar collector up to a pressurized fluid-to-outside-air-radiator, which comprises: a steam liquid separator between the solar collector and radiator to allow condensed steam, i.e. water, to flow back to the solar collector from the radiator, while allowing steam to pass from the solar collector to the radiator; a radiator above the~~

~~solar collector in which the pressurized steam condenses giving up its heat of vaporization and this heat is conducted via fins to the outside air, while keeping the condensed water inside the pressurized fluid loop; a means to keep condensable gases, like air, out of the fluid loop; a means to pressurize the fluid loop.~~

3. (currently amended): A ~~pressure activated~~ solar collector over-temperature protection ~~system for pressurized, antifreeze filled, fluid heat transfer loop from a solar collector to a hot water tank,~~ device which utilizes a steam pressure-actuated piston to open air dampers that allow outside air to flow over and cool the solar collector's absorber plate, where the piston is connected between the solar collector and the device to actively manage pressure/vacuum and eliminate non-condensable gases in a closed loop, unpressurized when cold, fluid filled, self-pressurizing, solar system, which is comprised of: a one-way out pressure relief valve and a one-way in vacuum relief valve plumbed in parallel from the highest point in the solar system to the bottom of an unpressurized, partially filled overflow/recovery reservoir. ~~solar collector air dampers as moving parts to allow outside air to flow over and cool the solar collector absorber plate, which comprises: a steam pressure activated mechanical actuator, which opens solar collector air damper valves before the system's regulated pressure is reached; a means to regulate maximum pressure in the fluid heat transfer loop; a set of damper valves, which control airflow over the solar collector heat absorbing panel, so when the air dampers are opened the sun's heat energy is dissipated to the ambient air flowing over the heat absorbing panel and when the dampers are closed the sun's heat energy is delivered to the heat transfer fluid within the solar absorbing panel.~~

4. (cancelled):

5. (cancelled):

6. (cancelled):

7. (cancelled):

8. (cancelled):

9. (cancelled)

10. (cancelled)

11. (cancelled)

12. (cancelled)

13. (currently amended~~new~~) A ~~boiling activated~~ solar collector over-temperature protection ~~system~~device ~~for pressurized, antifreeze filled, fluid heat transfer loop from a solar collector to a hot water tank,~~ which includes both a boiling-activated, liquid-to-air radiator and pressure-actuated air dampers which are both connected between the solar collector and the device to actively manage pressure/vacuum and eliminate non-condensable gases in a closed loop, unpressurized when cold, fluid filled, self-pressurizing, solar system, which is comprised of: a one-way out pressure relief valve and a one-way in vacuum relief valve plumbed in parallel from the highest point in the solar system to the bottom of an unpressurized, partially filled overflow/recovery reservoir~~a condensable gas (steam) heat pipe to carry excess heat from the boiling solar collector up to a pressurized fluid-to-outside air radiator, combined with a pressure activated solar collector over-temperature protection system for pressurized, antifreeze filled, fluid heat transfer loop from a solar collector to a hot water tank, which utilizes solar collector air dampers as moving parts to allow outside air to flow over and cool the solar collector absorber plate, which includes an active pressure control system and an air elimination system.~~

ABSTRACT

Delivering heat from modern high temperature solar collectors to hot water storage tanks is more effectively done using ~~a~~ unpressurized when cold, self-~~-~~pressurized on heat up, automatic air eliminating, higher temperature fluid loops. A pressurizing valve, an overflow reservoir and a vacuum relief valve are used. Non-toxic water/antifreeze mixtures are pressurized up to about two atmospheres resulting in a 265° Fahrenheit boiling point. Loss of circulation under full sun results in solar collector boiling under pressure. ~~A steam heat pipe is set up between the solar collector and the pressurized liquid-to-outside-air radiator.~~ The steam generated in the solar collector is condensed in the pressurized ~~liquid-to-air radiator~~liquid-to-air radiator, a steam heat pipe, and water is returned to the solar collector to keep it completely full of fluid and steam. A set of pressure~~- activated~~ actuated air dampers on the solar collector can also be used to shed the excess solar collector heat.